Engineering Across Cultures: New learning resources for intercultural competency in engineering

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BACKGROUND

The work described in this paper has emerged from an ALTC/OLT funded project, Exploring Intercultural Competency in Engineering. The project indentified many facets of culture and intercultural competence that go beyond a culture-as-nationality paradigm. It was clear from this work that resources were needed to help engineering educators introduce students to the complex issues of culture as they relate to engineering practice. A set of learning modules focussing on intercultural competence in engineering practice have been developed that cover the various aspects of culture in engineering identified in the project. Supporting the resources, an eBook detailing the ins and outs of intercultural competency has also been developed to assist engineering educators to embed opportunities for students to develop skills in unpacking and managing cross-cultural challenges in engineering practice.

PURPOSE

This paper argues that the Engineering Across Cultures eBook and learning modules provide a useful tool for creating opportunities for to develop their intercultural competence. The authors also propose a plan for establishing a community of practice in the area in intercultural competence in engineering education.

DESIGN/METHOD

A key aim of this project overall was to go beyond the culture-as-nationality approach adopted in much of the work around intercultural competency (Deardorff, 2011). The eBook explores different dimensions of culture such as workplace culture, culture's influence on engineering design, and culture in the classroom. The book describes how these connect to industry practice and explore what they mean for engineering education. The packaged learning modules described here have been developed as a matrix of approaches moving from familiar known methods through complicated activities relying to some extent on expert knowledge. Some modules draw on the concept of 'complex un-order' as described in the 'Cynefin domains' proposed by Kurtz and Snowden (2003).

RESULTS

Several of the modules included in the eBook have already been trialled at a variety of institutions. Feedback from staff has been reassuringly positive but the evaluation to this point is limited. Further trials are planned for second semester 2012, and version 1 of the eBook and learning modules, Engineering Across Cultures, is due to be released in late October 2012.

CONCLUSIONS

The Engineering Across Cultures eBook and learning modules provide a useful and ready to employ resource to help educators tackle the complex issue of intercultural competency in engineering education. The book is by no means exhaustive, and nor are the modules, they instead provide an accessible, engineering specific guide to bringing cultural issues into the engineering classroom.

KEYWORDS

Intercultural competency, engineering practice, learning resources

Introduction

The intercultural competence of engineering graduates is of growing importance. Our graduates operate in complex workplaces, often with regular interaction with suppliers, contractors and clients (Engineers Australia, 2011). Graduates can also progress to managerial roles just a few years after graduation, placing an even greater importance on their ability to understand the context in which they are working and to take responsibility for satisfactory outcomes from their work. To prepare graduates for this, engineering educators have a responsibility to ensure our students have ample opportunity to develop skills in identifying cultural norms and complexities and working with these effectively, not in opposition to them.

Through a number of workshops with engineering academics across Australia, we refined three focused statements describing intercultural competency as relevant to engineering practice. These statements frame our approach to developing the eBook and learning resources outlined later in the paper:

>**Culture:** *Values, beliefs and behaviours*

>**Intercultural Competency:** *Appreciating, respecting and adapting to other values, beliefs and behaviours and working with differences*

>**Challenges faced by graduates:** *Identifying and understanding values, beliefs, and behaviours of one's self and others*

The absence of specific reference to nationality or ethnicity in these statements is intentional. A core objective of the work described in this paper, concerns development of approaches to teaching intercultural competence that detach the term 'culture' from commonly accepted ideas like nationality or ethnicity. In this paper we describe the development of a series of learning modules and an accompanying eBook focussing on the development of intercultural competence in engineering students. We argue that these resources provide a useful starting point for improving education in this area, and for the development of an intercultural competency focused community of practice. In the interests of a logo and a nice acronym, we have branded the book and resources Engineering Across Cultures, or EAC.

The Modules

This work began as an audit of Graduate Capabilities of students in undergraduate engineering degree programs at the University of Wollongong, in 2008. Among other things, this audit found there was a lack of appropriate education addressing the graduate capability defined by the Faculty of Engineering as - *respect for views, values and culture of others*. With the aid of an internal grant and adoption of the EWB challenge in a first year design subject in 2010, a series of tutorial modules targeting the impact of culture on engineering design was developed and implemented. Details and outcomes of this are reported elsewhere (Goldfinch, Layton, & McCarthy, 2010). The need to do much more in this area was recognised and a successful application for ALTC funding in late 2010 enabled the expansion of the original work. The resources and eBook detailed here are a key outcome of this OLT (formerly ALTC) funded project exploring intercultural competency in engineering.

Foundations & Focus

It is common in this area to focus on issues of international interactions, particularly involving international students (Deardorff, 2011). In this project we extended the scope of the project to include five perspectives on culture that our research indicated will affect future career prospects of engineering students and graduates. With the input of many academics and other contributors through workshops and meetings, these five aspects of culture - as they

relate to engineering design, practice, and education – formed the structure for the development of the learning modules:

1. Living culture – Developing awareness and understanding of how engineering fits into social contexts

2. Workplace culture – Seeing how workplace cultures evolve and their effect on work practices

3. Community culture – Engaging with community issues that engineers often encounter

4. Technical/cultural demands – Exploring links between technical and cultural requirements in design and practice

5. Culture in the classroom – Identifying students' priorities and cultivating a classroom learning culture that is open and accepting of new ways of thinking (for the educator).

Conventional engineering education tends to separate the 'social' from the 'engineering'. As Warhafts noted (2005) "The broader implications of technological innovation are not addressed directly in the engineering classroom. Even in courses that consolidate and integrate knowledge, such as engineering design, the social issues are dealt with narrowly." The topics, which are the focus of this work, are too often dismissed by students, and some academics, as 'irrelevant for engineering' or 'for arts students, not applicable to the *real work* of engineering students'. To challenge this attitude and assist students appreciate the qualitative side of engineering practice, each EAC module either commences with, or works back to an example of how the focus issues affect – and are affected by – engineering practice.

Four sets of teaching modules (one for each aspect of culture identified above) are presented in three components, a student guide, a tutor guide, and supporting resources. The fifth set is specifically intended for use by academics and tutors to address the fifth aspect of culture and does not include student components. Table 1 shows all modules and their components. The student guides contain an overview of the class activity, learning outcomes, lists of resources and include questions to prompt exploration and guide activities. The intention is to provide students with enough information to aid the tutor in initiating each stage of the class without providing so much information that the flexibility of the class would be limited.

Tutor materials include substantial detail on how to run the class, how to facilitate group discussions, and how to prompt students to think more deeply about the tasks at hand. There are also strategies presented on how to set up collaborative learning spaces to best support the class activity format. It was evident that this level of detail is necessary to reduce the possibility of apprehensions about managing class activities that do not have pre-set 'correct' answers, and more effectively support tutors unable to attend regular teaching team meetings.

Supporting resources vary in format, content and style among the modules. The intention to provide a high level of flexibility is a particular feature of the modules. Through developing a range of resources and case studies for educators to choose from, the contexts in which the modules can be run can also vary widely.

Changing Teaching

A crucial component of the development of the EAC materials was providing adequate support for the educators responsible for delivering the modules. In addition to tutor guides for each module are the final three, teacher-only modules (EAC 13, 14, and 15). These modules present three overarching theoretical frameworks that underpin various aspects of the EAC teaching modules. All are chosen with the goal of engaging educators in a reflective approach to their own practice as a teaching academic, and detail strategies for how the EAC modules can be delivered.

The first framework (module 13) introduces the concept the "Project Portfolio Manager" as a way of positioning the role of the tutor in the class. All of the EAC teaching modules (1-12) rely upon group based learning. Module 13 asks the educator to conceptualise groups in the class as "projects" with defined outcomes (learning outcomes), limits and constraints, and work to be complete. As the Project portfolio manager, the educator sits just outside the projects they are managing. They are responsible for monitoring the progress of the project towards its stated goals, and intervening when these goals are not being met, but not to step in and do the work. Taking on board this conception of the EAC group activities means accepting that groups will progress towards the set goals in different ways and that the educator needs to evaluate and intervene only when necessary – responsibility for the groups progress towards the goals of the group activity must stay with the group. It also means that each group may produce slightly different outcomes.

The second framework presented in module 14 introduces the knowledge management concept known as the Cynefin Domains of Knowledge (Kurtz & Snowden, 2003) as a way of thinking about the forces found regularly in classrooms. It uses the concept of cause and effect relationships to explore five different conditions that may be found at different times in education. These conditions have informed the structure of activities for each of the EAC teaching modules (1-12). The Cynefin Domains are presented in figure 1 below. Traditional education mainly focuses on the 'ordered' domains on the right. The 'visible order' is the known cause and effect relationships such as the layout of a lecture theatre and subsequent function of a traditional lecture. The 'hidden order' describes the causes and effects that can be identified and repeated. These are discovered under the guidance of a teacher (i.e. lab classes, simple engineering mechanics problems).

The EAC materials aim to prepare students for working effectively in the 'un-ordered' domains on the left, since engineering challenges involving intercultural interactions are usually situated in these domains of chaos and complexity. EAC resource materials present cases or topics that simulate those encountered in engineering practice where students need to work with incomplete information. Activities in each module encourage them to work just sufficiently beyond current levels of knowledge so as to stretch their capabilities for absorbing, managing and responding to new information - and develop their self-confidence while doing so.

The shaded area in the middle of figure one is also important to the structure and delivery of the EAC modules. This fifth region is referred to by Kurtz and Snowden as 'Disorder'. It is often the starting point at which the relationship between cause and effect is not known. This region of the model can lead to distress and a retreat to inappropriate or ineffective strategies for dealing with the situation. To illustrate, this is similar to what can be observed in complex political debates where participants create an overly simplistic understanding of cause and effect in the ordered domains as opposed to the more appropriate, but less comfortable 'un-ordered' domains. In the EAC materials, this reaction is avoided by providing students with just enough guidance to explore complex scenarios and identify patterns. These patterns help students to understand the underlying culture of the scenario.
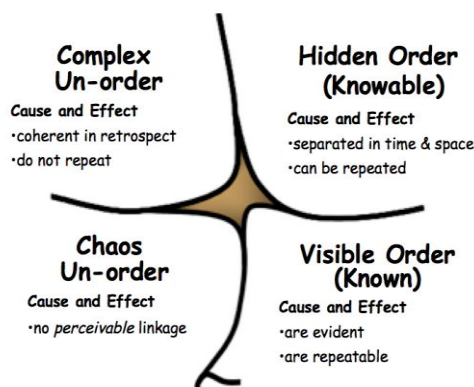
Figure 1 The Cynefin Domains of Knowledge (Kurtz & Snowden, 2003)

Finally, module 15 explores the significance, for educators, of current knowledge about how human beings learn. It emphasises the importance of understanding that there is a diversity of possible learning strategies. The module conveys this through an exploration of learning anecdotes and expected engineering student reactions to the approaches used in the EAC teaching modules. The module suggests ways in which this diversity can be incorporated into the educator's own teaching strategies to better support students in their progress through the 'un-ordered' methodology of each module.

Module overview

Table 1 presents a summary of each module and how it is intended to operate. This table illustrates the results of what has been achieved so far in our work developing strategies for exploring cultural issues in engineering education.

Table 1 – Engineering Across Cultures module overview

Module overview	Resources
Living culture – EAC 1-2-3 - Modules on awareness and understanding of engineering in general social contexts	
EAC 1 - How people live and the impact of engineering. An exploratory analysis linking familiar personal living contexts with unfamiliar [even 'strange'] modes from around the world.	Student guide
	Tutor guide
	8 scenarios
EAC 2 - Working with clients. Positions student in either client or consultant teams with the task of exploring client needs on the way to developing an engineering solution to a construction task. Possible assessable components.	Student guides
	Tutor guide
	7 client briefs
EAC 3 - Workplaces as Cultural Contexts. Uses four quite different case studies to examine how working contexts are influenced by cultural forces that may – or may not – be beneficial to those employed there. Possible assessable components.	Student guides
	Tutor guide
	4 case studies
Workplace Culture – EAC 4-5-6 – Modules on issues within the context of immediate experiences	
EAC 4 Analysing Engineering Relevance. Draws on an interview and transcript of a recovery response strategy following the 2004 tsunami. The Module is intended to be an introduction for students who will be completing some kind of engineering project process [e.g. EWB]	Student guides
	Tutor guide
	Scenario Transcript
EAC 5 Creating Culture - "Barnga". Employs a card game developed to demonstrate how culture is 'built' by those engaged in it. Invites exploration of forces –seen and unseen – that begin to shape routine behaviours	Tutor guide
	Game rules
	Case study reports
EAC 6 Exploring personal cultural stances - "Yes! No! Maybe!" Employs a simple board game strategy to assist students identify and examine their own current cultural values and perceptions.	Tutor guide
	Student guide
	Worksheets
Community Culture – EAC 7-8-9 – Modules on engagement with community issues engineers may encounter	
EAC 7 - Engineering in conflict with community. Uses a formal debating structure to draw students into an in-depth exploration of issues involved in a potentially divisive issue that has both social and engineering implications. Possible assessable components.	Coal Seam Gas resources
	Tutor Guide
	Student guide
EAC 8 – Culture as values in written texts [Minessence]. Employs a specific form a textual analysis to guide students through a process of analysing how organisational cultures may be expressed in written documents.	Tutor guide
	Student guide
	Resources
EAC 9 – Conceptualising engineering projects – My Best Bet. A team based activity that explores the forces identified when using a SWOT analysis of organisational contexts.	Tutor guide
	Student guide
	Game materials
Technical/Cultural demands – EAC 10-11-12 – Modules explore links among technical requirements and cultural requirements	
EAC 10 – "Fitting It All In" - culture in professions & trades. Uses a hypothetical building project to examine the kinds of issues that commonly arise when trying to 'fit in' all the essential elements in a building project.	Tutor guide
	Student guide
	Resources
EAC 11 - Technical aspects - Designs for the future. Students explore how initial solutions may – or may not – address the 'real' problems facing a design task.	Tutor guide
	Student guide
	Resources
EAC 12 – Solutions creating problems - Piper Alpha case study. A case study based on the Piper Alpha oil-rig explosion. Provides incomplete information and invites students to explore the events, and immediate and long-term results. Possible assessable components.	Tutor guide
	Student guide
	Resources
Culture in the Classroom – EAC 13-14-15 – Modules for teaching staff - supporting materials to help apply EAC	

teaching/learning strategies	
EAC 13 - Project Portfolio Management	Tutor guide
EAC 14 - Teaching on the edge of chaos	Tutor guide
EAC 15 - Teaching styles / learning styles	Tutor guide

While the resources have been constructed mainly as class activities, some incorporate outcomes and out-of-class work which can easily be developed into assessment tasks. Where 'possible assessable components' are included in a module this is indicated in Table 1. Each of the EAC modules 1-12 is designed to be used in isolation, the modules do not need to be used in sequence. In some modules, there are references within the tutor materials to other modules. This is done so that where more than one module is used in a course, there are opportunities to link modules to maintain continuity, particularly in the way learning activities operate.

Table 1 illustrates the broad range of focus topics that are covered in the modules. In addition, the modules apply many different educational approaches to ensure the resources are both flexible and diverse. Several of the modules, particularly modules 1-4, and 7-9, are very flexible in how the materials can be used. By just changing the resources package (case studies or focus topics), the student and tutor guides can be reused to form a new and quite different module for use across different subjects and year levels.

Issues of Implementation

In arguing that the EAC modules provide a useful tool for creating opportunities for to develop their intercultural competence there are two aspects to consider:

1. the appeal and usability of the modules
2. the impact on student learning

To this point, evaluation of the impact of the EAC modules on learning has been limited. Some of the challenges in doing this are discussed in a companion paper (Goldfinch, et al., 2012), but further work is needed in this area. In terms of the appeal and usefulness of the modules, however, there is early evidence to suggest the authors are on the right track.

EAC modules 1, 2, and 4 have been used in their current form at the University of Wollongong for the past 3 years to support the Engineers Without Borders Challenge in a first year design subject. The modules formed the first three weeks of tutorial exercises. Implementing the modules for the first time met scepticism, enthusiasm, and even mild terror from some tutors. These negative reactions were largely driven by concerns about perceptions of student acceptance of the materials. This experience was reported in detail in (Goldfinch, et al., 2010). Persistence and sufficient ongoing support, has ensured that the materials have been adopted as the norm for the subject, and positive feedback on the various activities has led to an invitation for the authors to redevelop the rest of the subject materials. Spring semester 2012 has since seen the implementation of EAC modules 3 and 13.

EAC module one has also been used in the first year design subject focusing on the Engineers Without Borders Challenge at the Queensland University of Technology and in a postgraduate humanitarian aid course at the University of Manchester. In both cases, the materials were met with some initial reluctance by tutors, followed by positive feedback and suggestions for further materials. As with any in-class activity, some students have needed more guidance and encouragement than others, but overall the modules implemented so far have been well received by students.

The modules have also been showcased at a number of workshops for engineering academics in Sydney, Launceston, Hobart, Brisbane, and Wollongong. Feedback from participants has been encouraging and requests for access to specific modules and the eBook indicates that the modules have appeal and there is genuine interest in developing intercultural competency in undergraduate and postgraduate engineering programs.

The eBook and Future Work

The eBook itself, Engineering Across Cultures, has been developed to provide a detailed but accessible (<40 pages) guide to the ideas around intercultural competency that have been identified over the course of the OLT project. The book is essentially a companion to the EAC learning modules. Often, books like this provide educators with great ideas and useful frameworks for education, but beyond this it is up to the reader/user to convert this into usable resources. As we all know, the realities of workloads and change management can prevent sustained action on these ideas. This is why we have constructed the eBook to introduce the relevant EAC modules throughout the text. We hope that this will provide the reader with a useable starting point for further work, and further increase the appeal and usability of the EAC modules.

The book covers the background to each of the modules and the purpose each module serves. We hope that the level of detail provided will enable engineering educators to either use the resources in their current form, or modify, adapt and redevelop them to suit the context of the subject they are to be delivered in. We hope to make the final version of the eBook and all the modules available online through the AAEE scholar website by the end of October 2012.

Development of a Community of Practice

As outlined earlier, some modules have already been adopted into existing courses across a variety of year levels. It became clear in doing this that it was often necessary to adapt the modules to suit either the content of the course or class timetables. The potential for adaptation allows the modules to be embedded into the local subject syllabus. This is an important feature in the uptake and longevity (appeal and usability) of the material and also with moving this issue into the mainstream rather than being seen as another 'bolt-on' concept. With this in mind, we are making the modules available in Microsoft word document format through direct correspondence with the modules authors. This is in addition to the pdf versions of modules being freely available online. This accessibility of the materials is another feature to encourage uptake and adaptation of the modules. Members of the project team have experienced other resource creation efforts where the level of computer literacy skill required has acted as a barrier to any change in the original resource and adaptation to suit the context. The low level of IT literacy required to modify these modules means that this barrier has been removed. The project team would now like to use this as a starting point for developing an "EAC" community of practice that builds upon this initial collection of EAC modules and contributes to the ongoing evaluation of this approach.

The Authors propose an approach based on a proven community of practice framework. The framework is summarised effectively by Mann and Chang (2010) and Kolikant et al (2006), both drawing from the original work of Wenger (1998). Communities of Practice demonstrate three key attributes: A purpose or focus area; an engaged collection of people; and a shared practice. In this case the focus of the community of practice would be the improvement of intercultural competency for ourselves and within our students and staff, engineering educators form the community of people (largely networks formed through AAEE), and the education of undergraduate and postgraduate engineering students being the practice shared by those in the community. Mann and Chang (2010) also summarise a set of seven principles for establishing a community of practice that are proposed here for establishing and maintaining the community of practice (Wenger, McDermott, & Snyder, 2002 in Mann anf Chang, 2010):

1. **Design for evolution** - To do this the research team are asking educators who modify the original modules to suit a particular context to return their modified versions to the collection in a share and share-alike approach. This will mean that the educational resources that form the focal point of the community's domain of knowledge can change and develop and the knowledge among the community grows.

2. It is anticipated that **a dialogue between inside and outside perspectives** can be achieved through feedback from users or community and workshops with those who have contact with the work produced by the community of practice, but are not engaged with its production or implementation. This will include student feedback in particular informing developments to the modules.

3. There are **opportunities for engagement with the community at different levels** through the use of existing or slightly modified modules, to development of new modules, to collaboration in research around the idea of intercultural competency.

4. Through unrestricted access to PDF versions of the modules online, and limiting word format versions to the community of practice, we aim to create opportunities for **public and private engagement with the community of practice**. This means that access to the materials produced by the community of practice is not limited only to those closely involved with it.

5. The **value** in participating in the community is achieved through ongoing support and guidance around the adaptation and redevelopment of the resources to suit the participant's context. We can also offer opportunities to collaborate on ongoing research around intercultural competency in engineering.

6. Establishing a level of **familiarity between members** to enable open discussions and sharing is a challenge that we hope is to overcome by working through existing AAEE networks that are collegial, open and friendly. Contrasting this, it is important to **also maintain excitement** about the creation of new teaching approaches and resources to sustain interest in the community of practice through continuing evolution of the materials and sharing of new ideas and perspectives.

7. Methods for establishing a **rhythm for the community of practice** (ie. Regular correspondence, outcomes, and events) will be a hurdle considering competing workload demands on academics. It is hope that connections can be maintained effectively by connecting community activities through existing regular commitments like the EWB Challenge and teaching semesters.

Aside from the development of new modules, we would also like to encourage those who implement modules to assist with the in-depth evaluation of their usefulness. Specific research questions we have at this point are:

- What are the barriers and enablers for intercultural competency in engineering education?

- How do students and staff engage with the EAC modules?

- How can we identify and measure improvements in intercultural competency?

Conclusion

The eBook and its associated learning modules presents a broader view of cultural issues in engineering practice, going beyond the boundaries of nationality or ethnicity. The Engineering Across Cultures learning modules and eBook provide a usable resource to help educators tackle complex cultural issues. The present stage of development is very encouraging with numerous enquiries from engineering educators and a number of universities trialling modules across different year levels. This suggests that the modules have both appeal and usability and appear to be a useful way forward in this area. Awareness of the need to address intercultural competencies both consciously and systematically using the Engineering Across Cultures modules should provide an expanding set of adaptations to meet the needs of courses and programs at different levels of complexity.

Using this eBook and the modules as a starting point, we can begin developing a community of practice around intercultural competency in engineering to produce rigorous education in this area. The Authors hope that the options presented here are only the beginning and that the learning modules available to the engineering education community can grow and be used widely. We also anticipate the continuation of work to research the benefits of this approach to students and engineering academics.

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